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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04N 5/32
A1
(11) International Publication Number: WO 98/03011
(43) International Publication Date: 22 January 1998 (22.01.98)

(21) International Application Number: PCT/EP97/03513
(22) International Filing Date: 3 July 1997 (03.07.97)

(30) Priority Data:
9614620.4 11 July 1996 (11.07.96) GB

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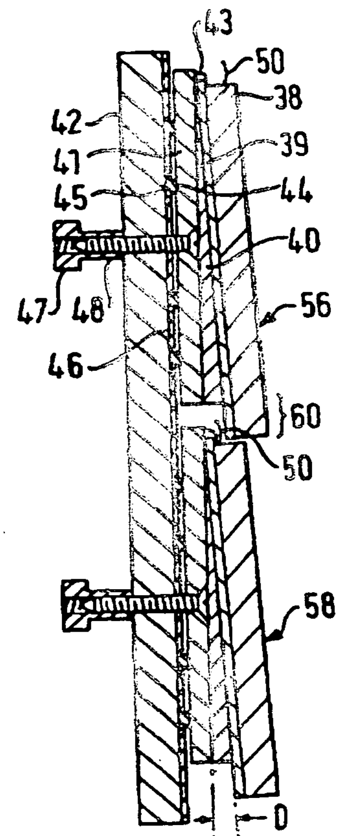
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: IMAGING APPARATUS HAVING A LARGE SENSING AREA

(57) Abstract

Imaging apparatus includes an imaging support and a number of imaging device tiles (56, 58). Each tile includes an imaging device having an imaging surface and has a non-active region (50) at or adjacent an edge of the tile. The imaging device on a tile mounted on said support is tilted such that a part of the imaging surface (60) of one tile at least partially overlies the non-active region of another tile, thereby providing substantially continuous imaging in a first direction. The space between tiles in the direction orthogonal to the first direction is minimsed by ensuring that the width of the imaging surface of a detector layer of the imaging device is the same as or greater than that of a readout layer of the imaging device and that of a mount for the imaging device.



IMAGING APPARATUS HAVING A LARGE SENSING AREA

The invention relates to imaging apparatus. The invention finds particular application to large area imaging.

Imaging systems are used in a wide range of applications, particularly for imaging for medical diagnosis, in biotechnology and in industrial applications for non-destructive testing and on-line product quality control.

For all of these fields of application, prevailing means of performing imaging is with the use of radiation, usually X-rays, gamma-rays and beta-rays. Radiation is detected by some sort of imaging plane, which need not be planar. Accordingly, the term imaging surface will be used hereinafter. Images are formed either directly on the imaging surfaces (e.g. projection imaging) or data are processed and images are reconstructed in a computer (e.g. computerized tomography or coded aperture imaging in nuclear medicine).

The traditional imaging surface was formed by a film in a cassette. Other imaging surface solutions have been developed over the past 40 years offering digital imaging. Such examples are NaI scintillating screens, NaI scintillating crystals, BGO crystals, wire gas chambers, digital imaging plates etc. More recently, semiconductor imaging solutions such as Charged Coupled Devices, Si microstrip detectors and semiconductor pixel detectors have been developed.

Typically, in all of the above cases, when a large imaging area is needed it is made either as a monolithic structure (e.g. films, digital imaging plates, NaI screens etc.) or as a mosaic of smaller pieces (tiles) put together and fixed on a support surface (e.g. gamma cameras with NaI crystals).

When a monolithic large imaging surface is employed, if a part of the surface is defective then the whole surface needs to be changed. Unfortunately, the most precise digital on-line imaging devices proposed so far involve pixel-based semiconductors which cannot be manufactured in large areas (larger than a few square cm at most). Moreover, it would not be desirable to manufacture, for example, a monolithic 30cm by 30cm digital imaging semiconductor surface because the yield would be low. If a portion of the expensive imaging area became defective, then the

whole surface would have to be replaced.

It has been proposed to provide a large area imaging surface (larger than a few square mm) using a tiling approach. In the applicant's patent application WO 95/33332, it has been proposed to employ a tiling approach. Using such an approach, individual imaging devices are arranged in an array, or mosaic on an imaging support to form a large area imaging mosaic Outputs from the individual imaging devices can be processed to provide a single output image corresponding substantially to the whole area covered by the imaging surface. However, when the imaging devices are tiled to form such a mosaic, dead spaces are left around the active imaging areas of the imaging devices. In order to deal with this problem it is proposed to stagger adjacent rows of imaging devices in the array and to provide for relative movement between an object to be imaged and the imaging array. Although such an approach does give good results and means that the effect of the dead spaces can be at least substantially eliminated, this does require the provision of the mechanism for the relative movement and appropriate software for processing the resultant multi-exposure image.

An object of the invention is to provide an imaging system and method which, while providing the advantages of the tiling approach, remove or at least mitigate the problems of the prior art.

In accordance with a first aspect of the invention, there is provided imaging apparatus comprising an imaging support and a plurality of imaging device tiles, wherein each tile comprises an imaging device having an imaging surface and has a non-active region at or adjacent an edge of the tile, the imaging device on the tile mounted on the support being tilted, or angled, such that part of the imaging surface of one tile at least partially overlies the non-active region of another tile, thereby provided substantially continuous imaging in a first direction.

Embodiments of the invention provide a new imaging mosaic system for producing imaging mosaics using a plurality of imaging devices tiles and an imaging support in a manner which reduces or substantially eliminates the dead spaces between tiles.

In a preferred embodiment, which enables the use of a planar support. each

tile comprises a mount having a mounting surface for mounting the tile on the support and a structure for carrying the imaging device on the mount such that the imaging surface is tilted with respect to the mounting surface. In the preferred embodiment of the structure comprises an intermediate member between the imaging device and the mount, the intermediate member being wedge-shaped to fully support the imaging device. However, alternatives are possible, for example spacers at one end of the tile.

In an alternative embodiment which enables the use of planar tiles, each tile comprises a mount having a mounting surface for mounting the tile on the support, the support provides a plurality of respective tile mounting locations on a support surface, the mounting locations being tilted to provide sawtooth deviations from the support surface, whereby the imaging surface of each imaging device is tilted with respect to the support surface.

Preferably the mount is planar and more preferably a printed circuit board.

Preferably also, the imaging device is planar, for example comprising a planar detector layer overlying a planar image readout layer, a surface of the detector layer forming the imaging surface. The detector layer can provide a plurality of detector cells and the readout layer can provide a plurality of corresponding readout circuits, each readout circuit being coupled to a respective detector cell.

In a preferred embodiment the detector layer is substantially rectangular, the readout layer is substantially rectangular and has a connection region which extends beyond the detector layer at one end thereof, the mount is substantially rectangular and has a connection region which extends beyond the readout layer at the one end, wired connections are provided between the connection regions of the readout layer and the mount, and the non-active region of the tile comprises the connection regions of the readout layer and the mount. The tile is preferably elongated in the first direction to minimise the angle of tilt and the effects of parallax.

Preferably, the tiles are mounted on the support such that the detector layers of adjacent tiles extend in a second direction perpendicular to the first direction so as almost or actually to touch each other.

Preferably, the imaging devices are positioned and held on the support in a

reversible and non-destructive way. The removable positioning/fixing means allow individual imaging devices to be removed multiple times so that the same imaging device can be used in a different imaging support or it can be replaced if found to be defective without damaging the imaging support and without affecting the operation of any other imaging device on the imaging support.

Preferably, the support provides a plurality of tile mounting locations, the removable mounting means removably mounting a respective tile at each location.

In preferred embodiments, each tile mounting location comprises a plurality of support contacts, each for co-operating with a respective tile contact for a transfer of signals between the support and the tile.

The support contacts can comprise recesses for receiving correspondingly shaped bumps on a tile or bumps for receiving correspondingly shaped recesses on a tile. More preferably, the support contacts comprise resilient conductive members overlying contact pads.

In a preferred embodiment, the imaging apparatus comprises a separate insulating substrate, which is located between the imaging device tile(s) and the imaging support and is aligned to enable electrical contact between each support contact and a corresponding tile contact via a respective resilient contact member. In this embodiment, each resilient conductive member is a ring having a hole for aligning bumps of the tile contacts or of the support contacts with corresponding contacts of the support, or corresponding contacts of the tile, respectively. The resilient conductive members can comprise conductive rubber, conductive polymers or metal springs.

Preferably, the mounting arrangement is adapted to apply an adjustable mounting force for removable mounting a tile at a tile mounting location. The mounting arrangement can comprise a hole for each tile mounting location, the hole being of appropriate diameter to accommodate securing means protruding from the tile. Fastening means for engaging with the securing means can be provided for each hole on the support at each tile mounting location. In a preferred embodiment, the fastening means is a nut and the securing means is a screw, the nut being adapted to be tightened on the screw after the imaging device tile has been positioned on the tile

mounting location with the screw extending through the hole, whereby the nut is used to secure the tile at the tile mounting location with an adjustable mounting force. The mounting arrangement can comprise a screw located or locatable at each imaging device tile location, for engaging with a threaded hole in a mount of an imaging device tile.

The imaging apparatus can comprise a plurality of different imaging supports and a common set of imaging device tiles which are mountable on a selected imaging support at any one time, but are removable, whereby they may be mounted on another one of the imaging supports.

In accordance with another aspect of the invention, there is provided an imaging support for apparatus as described, above, the imaging support providing a plurality of respective tile mounting locations on a support surface, the mounting locations being tilted to provide sawtooth deviations from the support surface. The support preferably comprises an arrangement for removable mounting an imaging device tile at each mounting location in a non-destructive, removable manner. The support enables the use of a planar imaging device tile.

In accordance with a further aspect of the invention, there is provided an imaging device tile for imaging apparatus as described above, wherein the tile comprises an imaging device having an imaging surface, a non-active region at or adjacent an edge of the tile, a mount having a mounting surface for mounting the tile on an imaging support and a structure for supporting the imaging device on the mount such that the imaging surface is at an angle to the mounting surface. This form of imaging device tile enables the use of a support which does not have sawtooth deviations for the tile mounting locations.

Embodiments of the invention are described hereinafter, by way of example only, with reference to the accompanying drawings in which:

Figure 1A is a schematic cross-sectional view of part of an imaging support;

Figure 1B is a schematic cross-sectional view of the part of the imaging support of Figure 1A with one example of an imaging device having a mount;

Figure 1C are a schematic view of the underside and apart cross-sectional view of the side of the imaging device mount for the imaging device of Figure B;

Figure 1D is a schematic cross-section view of apart of the imaging support of Figure 1B with the imaging device of Figure 1B mounted thereon;

Figures 2A - 2D are views corresponding to those of Figure 1 for a second example of an imaging device mount; and

Figure 3A is a schematic plan view of an arrangement of four imaging devices mounted on an imaging support in according with one example of the invention;

Figure 3B is a cross-sectional view of the arrangement of Figure 3A along line B-B; and

Figure 3C is an end view of the arrangement in figure 3A in the direction of arrow C in Figure 3A.

Before describing a particular embodiment of the invention, examples of possible approaches to removable mounting of imaging devices will be described. The removable mounting of imaging devices forms the subject-matter of the applicant's UK patent applications GB 9605978.7 and GB 9517608.7.

In a preferred embodiment of the present invention, by way of example only, the imaging devices comprise Active Semiconductor Imaging Devices (ASIDs) as described in the applicant's patent application WO 95/33332. An ASID is an active, dynamic semiconductor pixel imaging device with dimensions from, possibly, a few square mm to several square cm.

A cross-section of one such imaging device tile 24 is shown schematically in Figure 1B over a tile mounting location on a circuit board 9 of an imaging support. Figure 1A is a schematic cross-section illustrating the application of an insulating layer 29 and conductive rubber rings 16 over the circuit board 9. Figure 1C provides a view of the underside and a cross-section view of an imaging device mount (e.g. a PCB) 5. Figure 1D is a cross-sectional view of an imaging deice tile 24 secured at a tile mounting location by engagement of a nut 33 over a screw 31 of the imaging device tile 24.

The surface area of the imaging device 20 can vary depending on the application and the semiconductor materials chosen. Typical sizes are of the order of one square millimetre to several square centimetres, although the invention is not limited to imaging devices of these sizes. Radiation enters a semiconductor detector

1 from an imaging surface (the top face in Figure 1B) and upon absorption creates an electric charge. On the exit face of the detector layer 1, electrode pads (not shown) define the detector cells or pixels. Charge created from successive radiation hits is accumulated on the corresponding pixel circuits in a readout layer 3 which are connected to the detector pixels via conductive microbumps 2 (e.g. indium bumps - not shown). The pixel circuits are formed on a semiconductor readout chip which forms the readout layer 3. The imaging device 20, formed by the detector layer 1 and the readout layer 3, is mounted on a mount 4, for example a printed circuit board (PCB). The imaging device tile 24 is formed by the combination of the imaging device 20 and the mount 4.

Each imaging device 20 has tens of thousands of pixels but only needs around 5-15 external lines that will provide control signals, supply voltage and will readout the signal. These lines are provided on the PCB 4 and also on a circuit board 9 of an imaging support on which the imaging device tile 24 is mounted. The imaging device 24 itself carries a number of contacts 5 in the form of, for example, small metal spheres or bumps. The number of contacts typically corresponds to the number of external lines. The metal bumps 5 match an equal number of small appropriately sized contacts 7 on the circuit board 9 of the imaging support. The contacts on the circuit board 9 of the imaging support are connected to the aforementioned control, supply and signal lines (not shown). In the present example, an intermediate insulating layer 29 is provided between the imaging device mount 4 and the circuit board 9 of the imaging support. Holes 30 are provided in the insulating layer at positions corresponding to the metal bumps 5 and the contacts 7. Conductive rubber rings 16 are located in the holes 30 in the insulating layer 29.

Good electrical connection between each contact bump on the imaging device mount 4 and the corresponding contact 7 on the circuit board 9 is ensured by a separate conductive rubber ring 16. These are placed in appropriate holes of the electrically insulating layer 29, which is aligned and glued on top of the circuit board 9. The use of conductive rubber rings (i.e. with holes) is not essential, and conductive flexible pads could be used instead. However, the use of a ring structure with a central hole is advantageous for aiding alignment of the imaging device.

Alternatives to the conductive rubber rings 16, such as conductive polymers or metal springs, may be used. A screw 31 is glued into a hole 34 in the imaging device mount 4. This screw is pushed through the hole 32 in the circuit board 9 of the imaging support and is secured by the nut 33. The nut is tightened to press the metal balls 5 of the imaging device mount 4 against the rubber rings 16 which in turn are pressed against the metal pads 7 of the imaging support circuit board 9 ensuring good electrical contact.

This embodiment is particularly suitable for providing an imaging area comprising a plurality of easily removable semiconductor pixel imaging devices as described in WO 95/33332, or other types of pixel semiconductor imaging devices.

As individual imaging devices can be removed and re-positioned any number of times, the same imaging devices can be used in a number of applications. For example imaging devices used for mammography can be quickly transferred on a different imaging support for chest X-rays. A variety of imaging supports can have different sizes and shapes but only one set of imaging devices is needed. Additionally replacing an imaging device can be done by a non-expert and maintenance costs are minimized. Accordingly, contrary to the prior art where large imaging areas have monolithic imaging means or a fixed tiled imaging plane, the invention introduces a new large area imaging system where the imaging mosaic is made of removable imaging devices allowing for multi-purpose use and re-use of the individual imaging devices, while also allowing cost effective maintenance of the imaging areas.

If a particular example, e.g. mammography, is considered, an imaging surface of 30cm by 30cm (about 600 imaging devices of the type described in patent application WO95/33332) will be needed. The 600 imaging devices will be mounted on a printed circuit board 9 of the imaging support.

By means of the screws and nuts it is also possible individually to adjust the mounting force for each imaging device to ensure good alignment and good electrical contact using flexible contact elements such as the conductive rubber rings.

Alternatives to the specific example of the nuts and screws are possible while still retaining the advantages of this mounting approach. For example, wing nuts can be used to aid tightening and subsequent release of nuts. Also, the nuts could be

provided with an elongate form on the screws, and the holes in the support plane could be in the form of slits, so that the elongate nuts could be inserted through the slots and then tightened so that the elongate nut engages with the rear surface of the support plane. By suitably configuring the dimensions of the nut and the slot, an acceptable range of rotary adjustment could be provided.

As a further alternative, a rotatably mounted pin could be provided on the rear of the mount for the imaging device, which pin is provided with at least two perpendicular projections to be passed through an equivalently shaped key hold in the support plane, the pin then being turned after insertion through the keyhole so that the projections engage behind support plane to secure the imaging device.

Another example of an approach to the reversible and non-destructive mounting of imaging devices using screws is illustrated in Figure 2. The four schematic views 2A, 2B, 2C and 2D correspond generally to those of Figure 1, except that in this case the mount 5 of the imaging device is provided with a threaded hole 35 into which a screw 36, which is rotatably mounted at an imaging device location on the support plane 9, could be engaged to secure the imaging device to the support plane. The screw 36 could be inserted through a hole 32 in the support plane 9 at the imaging device location when it is desired to attach an imaging device at the location.

Alternatively, and as shown in Figure 2, the screw could be permanently mounted, in a rotatable manner, at the imaging device location. For example a neck on the screw could be mounted in a collar 37, which collar is then attached over the hole 32 in the support plane at an imaging device location so that the screw 36 is rotatably mounted at that location. In this example, the imaging device support will have an array of upstanding screws 36 to which the imaging devices with threaded holes can be attached. This example provides advantages as regards ease of use.

As an alternative to a screw 36 and threaded hole 35 in this embodiment, other similar arrangements, for example a stud with bayonet pins rotatably mounted in the support plane 9 and cooperating hole with bayonet pin receiving structures on the mount 5 could be provided.

Now that examples of techniques for the non-destructive mounting of imaging

devices has been described, the use of such techniques in an embodiment of the invention will be described. It will be noted in Figures 1B and 2B, that there are two steps at the left hand end of the imaging device. The first step 12 is between the detector 1 and the readout chip 3, and the second step 14 is between the readout chip 3 and the mount 4. The purpose of these steps is to enable the connection of bond wires (not shown) between contact pads on the readout chip and respective contact pads on the mount 4. This provides for the external electrical interface of the readout chip to the metal bumps 5 mentioned previously. In the readout chip, all internal electrical connections are brought to a single end of the chip to facilitate this connection and also to reduce the amount of dead imaging area for a mosaic of imaging device tiles. It will be appreciated that when the imaging devices tiles are arranged side-by-side and end-to-end, dead spaces (i.e. areas over which the detector does not extend) occur at the stepped region described above. Also, in conventional tiled arrays, spaces between adjacent imaging devices arranged side-by-side occur as the supports are wider than the detector surfaces. Approaches to dealing with this problem have been proposed which involve staggering adjacent rows of imaging devices on an imaging array and then providing for relative movement between an object to be imaged and the imaging array. This means that the effect of the dead spaces can be at least substantially eliminated, but this does require the provision of the mechanism for the relative movement and appropriate software for processing the resultant multi-exposure image.

Embodiments of the present invention provide a mechanism which can mitigate or completely eliminate the disadvantages of the prior approaches.

Part of an embodiment of the invention is illustrated, schematically, in Figure 3. In this embodiment the structure of the individual tiles is modified to enable adjacent tiles to be mounted very close to or even touching each other. The tiles can be connected both electrically and mechanically to the support plane in, for example, one of the ways described above, although other suitable mounting techniques could be employed.

In the particular embodiment shown in Figure 3, electrical connection between an imaging device mount (e.g. tile PCB) 41 and a support plane 42 is achieved by the

contact between conductive (e.g. metal) balls 44 on the tile PCB 41 and conductive rings 45 (e.g. of rubber), placed in appropriate holes in an electrically insulating intermediate plane 46, which is aligned and glued on top of the support plane 42 so that the rings 45 overlie contact pads (e.g. of metal) on the support plane 42. Mechanical connection is assured by means of a screw 48, which is glued into a hole in the tile PCB 41. This screw is pushed through a hole in the support plane and secured by a nut 47. The nut 47 is tightened to press the metal balls 44 of the tile PCB 41 against the rings 45 which in turn are pressed against the metal pads of the support plane ensuring good electrical contact.

In this embodiment, the signal detecting element (i.e. the detector 38 and the readout chip 39) it tilted, or angled, by applying a support part 40 of triangular or wedge shape between the tile PCB 41 and the readout chip 39. One edge of the detector 38 and the readout chip 39 can then be extended to cover the wire bond pads and the bond wires 43 of the neighbouring imaging tile. The wire bond pads are provided on the tile PCB 41 for the attachment of bond wires 43, which enable the pixel circuits on the readout chip to be electrically connected to the tile PCB 41. In this way the dead space which would otherwise be present between the imaging tiles when mounted on the support plane 42 is minimized or even completely eliminated. The elimination of this dead space means that alternative techniques to provide complete image coverage (for example, moving the support plane 42 and taking multiple exposures) are not required.

In this embodiment a rectangular shape of individual imaging tiles with one elongated side (preferably as long as possible) is chosen to minimize the parallax error caused by the tilting (i.e. minimize the tilting angle). For example, the dimensions of the detector 38 and the readout chip 39 can be 18mm by 10mm but many other dimensions are possible depending on the processing of the chip 39 and the detector 38. Figure 3A shows a planar view of the tile arrangement (four tiles in this example, although there will typically be many more tiles in an array). Figure 3B is a cross-sectional view at B-B. Figure 3C is an end view in the direction of the arrow C.

In Figure 3A, the bonding wires 43 and the stepped uppermost end 50 of the

uppermost imaging device tiles 52, 54 (as viewed in Figure 3A) can be seen. However, the bonding wires 43 and the stepped uppermost end 50 of the lowermost imaging device tiles 56, 58 (as viewed in Figure 3A) cannot be seen as these are covered by the lowermost end 60 of the uppermost imaging device tiles 52, 54 when viewed from above (i.e. looking down on the plane of Figure 3A). This is as a result of the tilting of the signal detecting elements comprising the detector 38 and the readout chip 39 as can be seen in the cross-sectional view of Figure 3B. In the particular example shown Figure 3, where the detector 38 and the readout chip 39 are approximately 18mm by 10mm, and the tilt provides a difference in the "height" (i.e. the horizontal distance D as viewed in Figure 3B) of the imaging device over the support board between the ends of the imaging device of about 1mm, the angle of tilt of the imaging device and the imaging surface is about 3°.

The space between tiles in the direction orthogonal to the tilting direction (which corresponds the section line B-B) is preferably minimised by ensuring that the width of the imaging surface of the detector 38 (i.e. in the horizontal direction as viewed in Figure 3A) is the same as or greater than that of the readout chip 39 and the tile PCB 41. In this manner, the tiles can be mounted so that the detectors actually touch or are separated by a very small amount in that direction.

With an embodiment of this type, the dead space introduced by the bonding pads, bonding wires and readout buffers (decoders, multiplexers etc.) on the readout chip 39 and the dead space introduced by the tile PCB 41 is eliminated because there is overlap of the total dead region with the detecting element 38 of the previous tile. Also, there is minimal or no dead space at all between tiles in the other direction since tiles are configured to be substantially proximate to or to touch each other and the detector elements 38 may indeed be configured to be precisely equal or extend slightly beyond the dimensions of the readout chip 39.

While in Figure 3 an arrangement of four tiles is shown it can be appreciated that any number of tiles can be arranged to provide an imaging area with any practically useful size, for example 45cm by 40cm. Also, although in the above described embodiments reference is made to a support plane, this need not in fact be planar, but could curved or shaped to fit form a desired imaging plane. For example

the imaging support could be shaped as part or the whole of a ring for certain applications.

The contacts on the imaging support are connected in turn to control electronics and output electronics for the imaging array. The output electronics include one or more analogue to digital converters for converting analogue signals from the imaging devices into digital signals for processing and displaying image data. An example of suitable control and output electronics and an image processor is described in the applicant's International patent application WO 95/33332. This International patent application also described examples of semiconductor pixel imaging devices suitable for use with the present invention. Thus, the signal detecting elements referred to above can, for example, be an imaging device which provides an array of imaging cells (or pixels) each including a radiation detector cell and corresponding charge storage for storing charge directly resulting from radiation incident on the radiation detector cell, the charge storage of respective imaging cells being individually addressable for charge readout and/or resetting. However, it should be noted that imaging devices other than semiconductor pixel devices may be used, such as removable CCDs, NaI crystals or small scale wire gas chambers.

An embodiment of the invention thus provides a stationary tiled imaging area with minimum or indeed no dead space at all, this embodiment providing tilting of the tiles in the direction of maximum dead space and allowing for overlap between the detecting element of one tile and the dead area of an adjacent tile. In the other orthogonal direction, tiles are arranged as proximate to each other as possible or even touching each other. All tiles are individually removable as previously thus offering an ideal digital imaging plane that can be maintained in parts without compromising the performance.

Although in the embodiment of Figure 3, a wedge-shaped part is shown between a planar detecting element and a planar PCB mount, it will be appreciated that alternative constructions may be employed to provide the angled arrangements of the imaging surface of the detecting element. For example, blocks along one edge, rather than a wedge-shaped part may be used. Also, the imaging device or the mount may be wedge shaped, or provided with integral supports at one edge for an angled

mounting. Alternatively, the mounting locations of the imaging support could be angled (tilted), or wedge-shaped, at each mounting location for the imaging devices to provide the angled and overlapping mounting of those devices.

Using an embodiment of the invention, for example with the mounting techniques described above, it is possible to configure a variety of clinical equipment with the imaging supports ready and mounted on the corresponding systems awaiting for the imaging devices. Imaging devices can be properly packaged and supplied separately from the rest of the imaging system and any average technical employee can handle them and relocate them from one plane to another. In this way, the use of the relatively expensive pixel semiconductor imaging devices is optimized by requiring less imaging devices than are needed simultaneously to equip all systems. In addition, maintenance becomes cost effective. A defective imaging device can be substituted rather than the whole imaging surface (mosaic) and this can be done easily by an average technical employee.

The removable securing can be achieved in a non-destructive way such that an imaging devices may be secured to and removed from an imaging support a plurality of times leaving the imaging device, the board(s) and corresponding contacts in substantially the same state.

The removable mounting may be achieved using alternative techniques including:

- reduced air pressure, or vacuum as described above, whereby the imaging devices are such into position;

- screws glued to the PCBs or other mounting means of the imaging devices and then pushed through corresponding holes in the support plane (e.g. the circuit board of the imaging support), the screws being then secured by nuts on the opposite side of the support plane;

- a socket configuration (preferably zero-insertion force socket means) whereby the imaging devices have pins that plug into corresponding sockets on the support plane;

- clips, whereby the imaging devices are kept in position with mechanical clips, strings or the like;

- magnets, whereby small magnets, either on the imaging support or on the imaging devices, or both, secure the imaging devices to the imaging plane;

- other mechanical arrangements.

The invention can be used for any radiation type in any radiation imaging field where areas larger than a few square mm are needed. In particular it finds application in medical diagnosis imaging with X-rays and gamma-rays, in biotechnology imaging with beta-rays (where isotopes are used as labels on the samples to be image) and in industrial applications for non-destructive testing and product quality control.

While specific embodiments have been described, it is to be understood that many modifications and alternatives can be made without departing from the invention.

For example, in the embodiment described with reference to Figure 3, the tiles are tilted with respect to one axis (one direction) with adjacent rows of tiles being arranged so that the detector areas substantially touch each other. However, in an alternative embodiment, it is possible for the tiles to be tilted with respect to two axes (i.e. about two orthogonal directions, each parallel a respective side of a square tile or about a single axis which passes through two opposite corners of a tile) so that dead regions along two adjacent edges of one tile may be covered by the detector imaging surface of two adjacent tiles which meet at the corner between those adjacent edges. In order to visualise this embodiment, it is helpful to think of the tiles being arranged like the scales of a fish or in diamond shapes rather than as a rectangular array of rows and columns of tiles. In other words, for any one tile, two edges which have dead spaces either side of a first corner will be lower than the two opposite edges either side of the opposite corner. Thus the dead spaces of the two lower edges of the tile in question will be covered by the detector imaging surface at the higher edges of two respective adjacent tiles. Also, the opposite, higher edges of detector imaging surfaces of the tile in question will overlie part of the dead space at the edges of two further adjacent tiles. For such an alternative embodiment, it is advantageous for the tiles to be substantially square as opposed to being elongated rectangles. This embodiment if useful for imaging devices having bond wire

connections or other dead spaces along two edges, rather than along a single edge as in the preferred embodiment of Figure 3.

CLAIMS

1. Imaging apparatus comprising an imaging support and a plurality of imaging device tiles, wherein each tile comprises an imaging device having an imaging surface and has a non-active region at or adjacent an edge of the tile, said imaging device on said tile mounted on said support being tilted such that part of said imaging surface of one tile at least partially overlies said non-active region of another tile, thereby providing substantially continuous imaging in a first direction.

2. Imaging apparatus according to Claim 1, wherein each tile comprises a mount having a mounting surface of mounting said tile on said support and a structure for carrying said imaging device on said mount such that said imaging surface is tilted with respect to said mounting surface.

3. Imaging apparatus according to Claim 2, wherein said structure comprises an intermediate member between said imaging device and said mount.

4. Imaging apparatus according to Claim 3, wherein said intermediate member is wedge-shaped.

5. Imaging apparatus according to Claim 1, wherein each tile comprises a mount having a mounting surface for mounting said tile on said support, said support provides a plurality of respective tile mounting locations on a support surface, said mounting locations being tilted to provided sawtooth deviations from said support surface, whereby said imaging surface of each imaging device is tilted with respect to said support surface.

6. Imaging apparatus according to any one of Claims 2 to 5, wherein said mount is planar.

7. Imaging apparatus according to any preceding Claim, wherein said imaging

device is planar.

8. Imaging apparatus according to any preceding Claim, wherein said imaging device comprises a planar detector layer overlying a planar image readout layer, a surface of said detector layer forming said imaging surface.

9. Imaging apparatus according to Claim 8, wherein said detector layer provides a plurality of detector cells and said readout layer comprises a plurality of corresponding readout circuits, each readout circuit being coupled to a respective detector cell.

10. Imaging apparatus according to Claim 9, wherein said detector layer is substantially rectangular, said readout layer is substantially rectangular and has a connection region which extends beyond said detector layer at one end thereof, said mount is substantially rectangular and has a connection region which extends beyond said readout layer at said one end, wired connections are provided between said connection regions of said readout layer and said mount, and said non-active region of said tile comprises said connection regions of said readout layer and said mount.

11. Imaging apparatus according to any one of Claims 8 to 10, wherein said tiles are mounted on said support such that said detector layers of adjacent tiles extend in a second direction perpendicular to said first direction so as almost or actually to touch each other.

12. Imaging apparatus according to any preceding Claim, comprising an arrangement for removably mounting said tiles on said imaging support in a non-destructive, removable manner.

13. Imaging apparatus according to Claim 12, comprising a plurality of tile mounting locations, said removable mounting means removably mounting a respective tile at each said location.

14. Imaging apparatus according to Claim 13, wherein each tile mounting location comprises a plurality of support contacts, each for co-operating with a respective tile contact for a transfer of signals between said support and said tile.

15. Imaging apparatus according to Claim 14, wherein said support contacts comprises recesses for receiving correspondingly shaped bumps on a said tile or bumps for receiving correspondingly shaped recesses on a said tile.

16. Imaging apparatus according to Claim 15, wherein said support contacts comprise resilient conductive members overlying contact pads.

17. Imaging apparatus according to Claim 16, comprising a separate insulating substrate, said resilient conductive members being provided in holes in said separate insulating substrate, which is located between said imaging device tile(s) and said imaging support and is aligned to enable electrical contact between each said support contact and a corresponding tile contact via a respective resilient contact member.

18. Imaging apparatus according to Claim 16 or Claim 17, wherein each resilient conductive member is a ring having a hole for aligning bumps of said tile contacts or of said support contacts with corresponding contacts of said support, or corresponding contacts of said tile, respectively.

19. Imaging apparatus according to any one of Claims 16 to 18, wherein said resilient conductive members comprise conductive rubber, conductive polymers or metal springs.

20. Imaging apparatus according to any one of Claims 12 to 19, wherein said mounting arrangement is adapted to apply an adjustable mounting force for removable mounting a tile at a tile mounting location.

21. Imaging apparatus according to Claim 20, wherein said mounting arrangement

comprises a hole for each tile mounting location, said hole being of appropriate diameter to accommodate securing means protruding from said tile.

22. Imaging apparatus according to Claim 21, wherein fastening means for engaging with said securing means is provided for each hole on said support at each tile mounting location.

23. Imaging apparatus according to Claim 22, wherein said fastening means is a nut and said securing means is a screw, said nut being adapted to be tightened on said screw after said imaging device tile has been positioned on said tile mounting location with said screw extending through said hole, whereby said nut is used to secure said tile mounting location with an adjustable mounting force.

24. Imaging apparatus according to any one of Claims 12 to 23, wherein said mounting arrangement comprises a screw located or locatable at each imaging device tile location, for engaging with a threaded hole in a mount of an imaging device tile.

25. Imaging apparatus according to any preceding Claim, comprising a plurality of different imaging supports and a common set of imaging device tiles which are mountable on a selected imaging support at any one time, but are removable, whereby they may be mounted on another one of said imaging supports.

26. An imaging support for apparatus according to any preceding Claim, said imaging support providing a plurality of respective tile mounting locations on a support surface, said mounting locations being tilted to provide sawtooth deviations from said support surface.

27. A support according to Claim 26, comprising an arrangement for removable mounting an imaging device tile at each mounting location in a non-destructive, removable manner.

28. An imaging device tile for imaging apparatus according to any one of Claims 1 to 25, wherein said tile comprises an imaging device having an imaging surface, a non-active region at or adjacent an edge of the tile, a mount having a mounting surface for mounting said tile on an imaging support and a structure for supporting said imaging device on said mount such that said imaging surface is at an angle to said mounting surface.

29. An imaging device tile according to Claim 28, wherein said structure comprises an intermediate member.

30. An imaging device tile according to Claim 29, wherein said intermediate member is wedge-shaped.

31. An imaging device tile according to any one of Claims 28 to 30, wherein said mount is planar.

32. An imaging device tile according to any one of Claims 28 to 31, wherein said imaging device is planar.

33. An imaging device tile according to any one of Claims 28 to 32, wherein said imaging device comprises a planar detector layer overlying a planar image readout layer, a surface of said detector layer forming said imaging surface.

34. An imaging device tile according to Claim 33, wherein said detector layer provides a plurality of image detector cells and said readout layer comprises a plurality of corresponding readout circuits, each readout circuit being connected to a respective image detector cell.

35. An imaging device tile according to Claim 34, wherein said detector layer is substantially rectangular, said readout layer is substantially rectangular and has a connection region which extends beyond said detector layer at one end thereof, said

mount is substantially rectangular and has a connection region which extends beyond said image readout layer at said one end, wired connections are provided between said connection regions of said readout layer and said mount, and said non-active region of said tile comprises said connection regions of said readout layer and said mount.

36. An imaging device tile according to any one of Claims 28 to 35, comprising means for removably mounting said tile at a tile mounting location on an imaging support in a non-destructive, removable manner.

37. An imaging device tile according to any one of Claims 28 to 36, in the form of a pixel semiconductor imaging device.

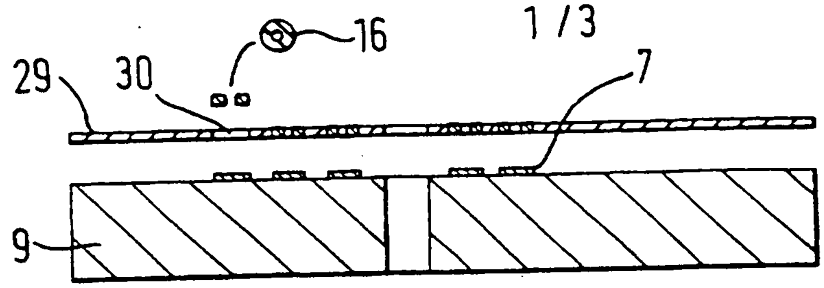


FIG. 1A

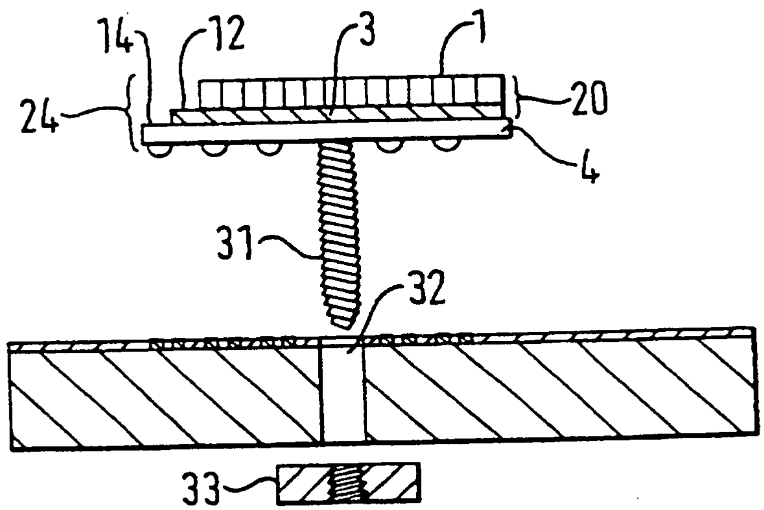


FIG. 1B

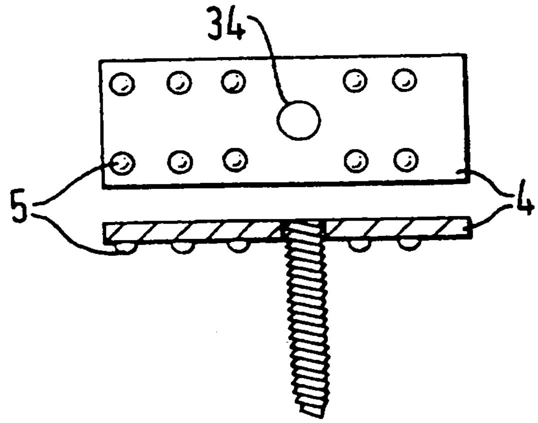


FIG. 1C

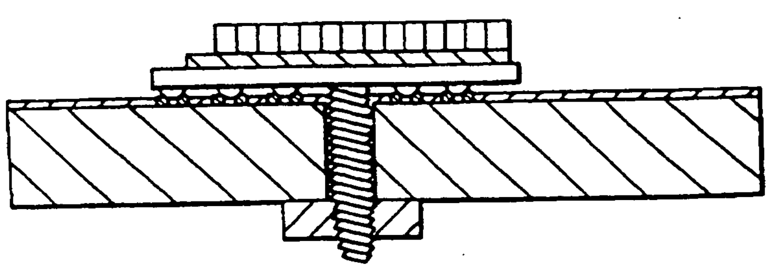


FIG. 1D

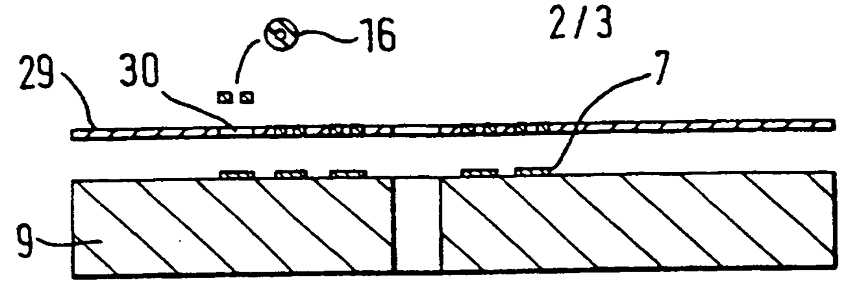


FIG.2A

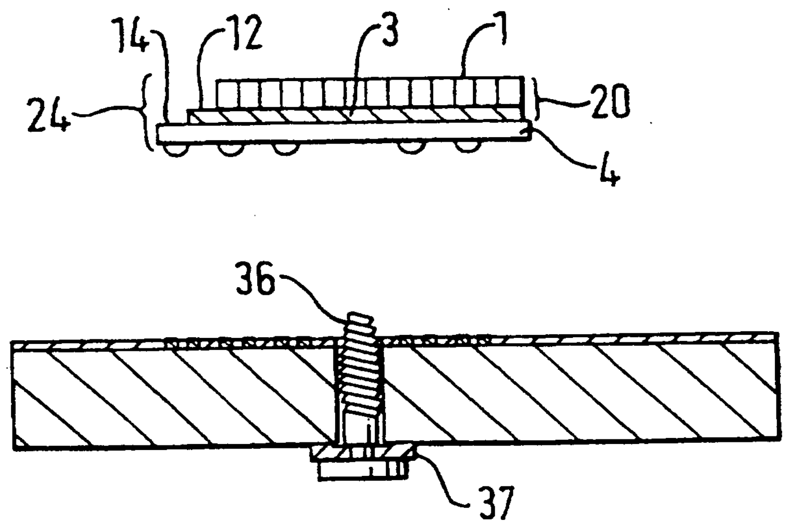


FIG.2B

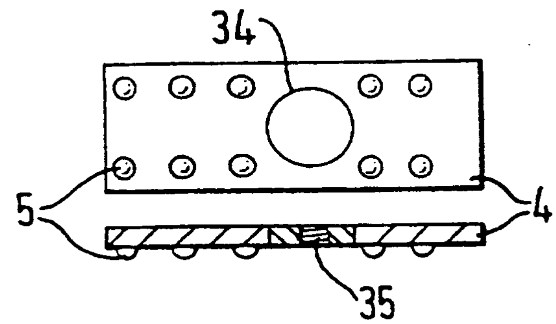


FIG.2C

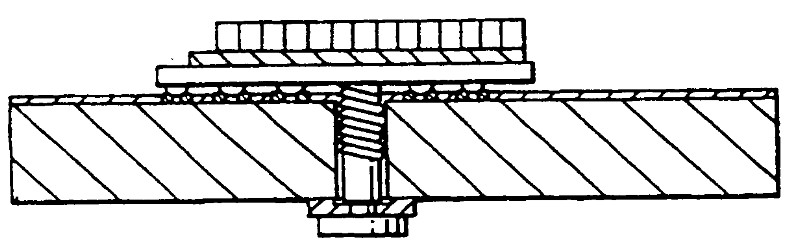


FIG.2D

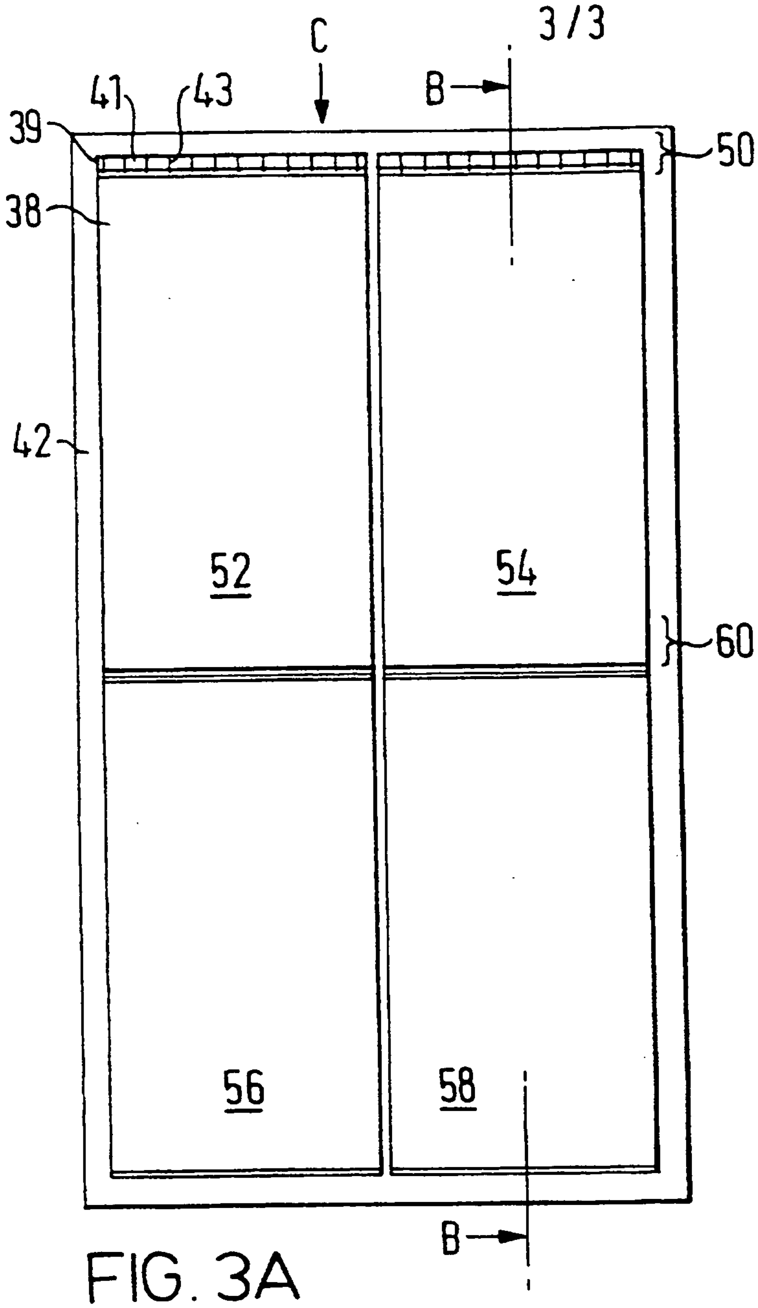


FIG. 3A

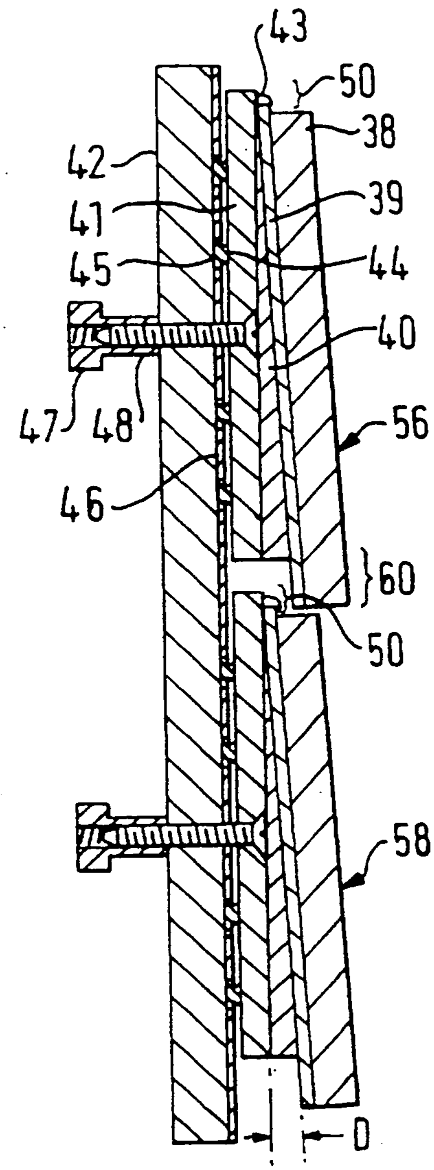


FIG. 3B

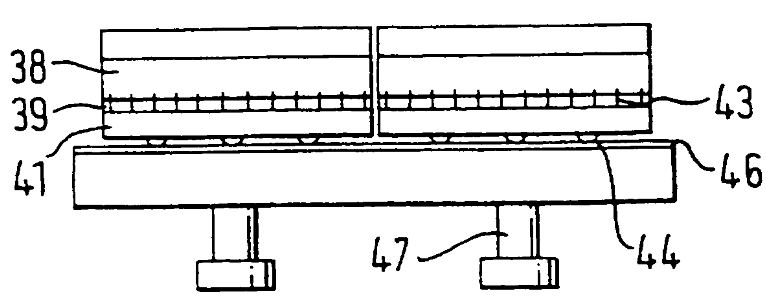


FIG. 3C

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 97/03513

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N5/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04N G01T H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 291 351 A (SHIMADZU CORP) 17 November 1988 see column 3, line 18 - column 4, line 52	1
A	US 3 939 555 A (JANTSCH OTTOMAR ET AL) 24 February 1976 see column 5, line 43 - line 56 see figure 6	5,26
A	EP 0 421 869 A (COMMISSARIAT ENERGIE ATOMIQUE) 10 April 1991 see column 2A, line 46 - column 3, line 45 see column 4, line 5 - column 5, line 29	28-37
A	US 5 065 245 A (CARNALL JR EDWARD ET AL) 12 November 1991 see column 1, line 66 - column 2, line 7	12,26

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
16 October 1997	29.10.97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Wentzel, J

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte. onal Application No
PCT/EP 97/03513

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0291351 A	17-11-88	JP 63284485 A	21-11-88
		CN 1037595 A,B	29-11-89
		US 4914302 A	03-04-90
US 3939555 A	24-02-76	DE 2235680 A	07-02-74
		FR 2194047 A	22-02-74
		GB 1393627 A	07-05-75
EP 0421869 A	10-04-91	FR 2652655 A	05-04-91
		CA 2026808 A	05-04-91
		JP 3137589 A	12-06-91
US 5065245 A	12-11-91	EP 0479996 A	15-04-92
		JP 4506893 T	26-11-92
		WO 9117624 A	14-11-91
EP 0262267 A	06-04-88	US 4755681 A	05-07-88
US 4467342 A	21-08-84	NONE	